IoT Based Parameter Monitoring of Three Phase Induction

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Abstract : Condition monitoring has become an important research with new developing technologies to diagnose the faults in induction motors. The condition based monitoring of the induction motor has been a important task for technicians, engineers, researchers mainly in industrial application such as railway, pumps, conveyors, blowers, elevator, mining industry, etc. Nowadays induction motors are the preferred choice among the industrial motors due to their rugged construction, the absence of brushes, the modern power electronics, and the ability to control the speed of the motor. Induction machines are used as actuators in many industrial processes. Although induction motors are reliable, they are subjected to some undesirable stresses, causing faults resulting in failure. Monitoring of an IM is a fast up-and-coming technology for the detection of initial faults. This paper proposes a wireless control and monitoring system for an induction motor based on Internet of things protocol for safe and economic data communication in industrial application. A microcontroller based system is used for collecting and storing data and accordingly generating control signal to stop or start the induction machine through Ethernet shield is used to interface developed with IoT.

Index Terms **– Monitoring, Induction Motor, Internet of Things.**

I. INTRODUCTION

Condition monitoring is considered as a key element of induction motor which ensure to continuously reduce and eliminate cost unscheduled downtime and unexpected breakdowns [1#]. This paper has been presented a review on major research and developments over the past few decades in the condition monitoring and fault detection of induction motor. Induction motors are the majority of the prime movers in industrial application for their reliability . The demand of three phase induction motor has highly expanded in recent years because of their simplicity and reliability of construction [2]. The induction motors are widely used in the industry for railway application, mining industry, wood working machines, automotive industry, chemical industry, paper mills, etc. Single phase induction motors are most useful in domestic application and industrial machines, due to their high efficiency and reliability. Authors have studied a variety of faults in three phase induction motors, such as unbalanced stator, winding faults, rotor parameters, eccentricity, bearing faults and broken rotor bars have been studied by [3-5].

A conventional maintenance technique in the industry has taken two types, based on fixed time interval maintenance and failure of plant as and when it happens. However, To improving the condition monitoring of induction motor using today's technology. The key elements of this new technique are condition based maintenance or predictive maintenance through condition monitoring, which depends upon the condition of the plant [6-7]. The condition based monitoring is used for increasing the performance of the induction motor, increasing machine life, reducing internal and external damage, reducing [8].The condition monitoring and fault detection of induction motors have become necessary to stop the unexpected machine shutdown. There several techniques used for condition monitoring of induction motors such as vibration signature analysis, acoustic emission monitoring, motor current signature analysis (MCSA), but these monitoring techniques are complex and require expensive sensors [9]. An efficient condition-monitoring scheme is capable of providing warning and predicting the faults at early stages. The condition monitoring system collects primitive data information about the motor using signal processing or data analysis techniques. The major problem of this type of approach requires human interpretation [10]. The automation of the fault detection and diagnostic process is a logical progression of the condition-monitoring technologies [11]. The automate fault detection and diagnostic process require an intelligent system such as artificial intelligence techniques, neural network, genetic algorithm, fuzzy logic and expert system [12] . A very useful survey of high voltage induction motor failures from industry using different type of categorization, including protection scheme, machine size, age, number of poles, maintenance regime and running hours [13]. The authors investigate the cause of the stator and bearing faults which together 75% of all failures in the induction machine [14].

II. CONTROLLING AND MONITORING SECTION

The overall structure of the system hardware is shown in Fig. 1. This section presents overview about the parameter monitoring arrangement of three phase induction motor. A general block diagram of parameter monitoring system using IoT has been presented in this paper .The whole arrangement is divided into following parts transmitter and receiver. Transmitter system consist of sensors, transducers and microcontroller which are used to acquire the parameters such as temperature, speed sensors for three phase induction motor located at distant location. Acquired parameters are then send to Arduino for display through LCD (Liquid Crystal Display) and transmitting end is IoT platform. Measured values are then compared with set values through vb.net program and if in any case the measured value exceeds the set value of any parameter controlling signal will be generated by microcontroller to take proper control action such as to stop the motor, switch on fan on motor side, adjust the speed depending on the measured value of the parameter.

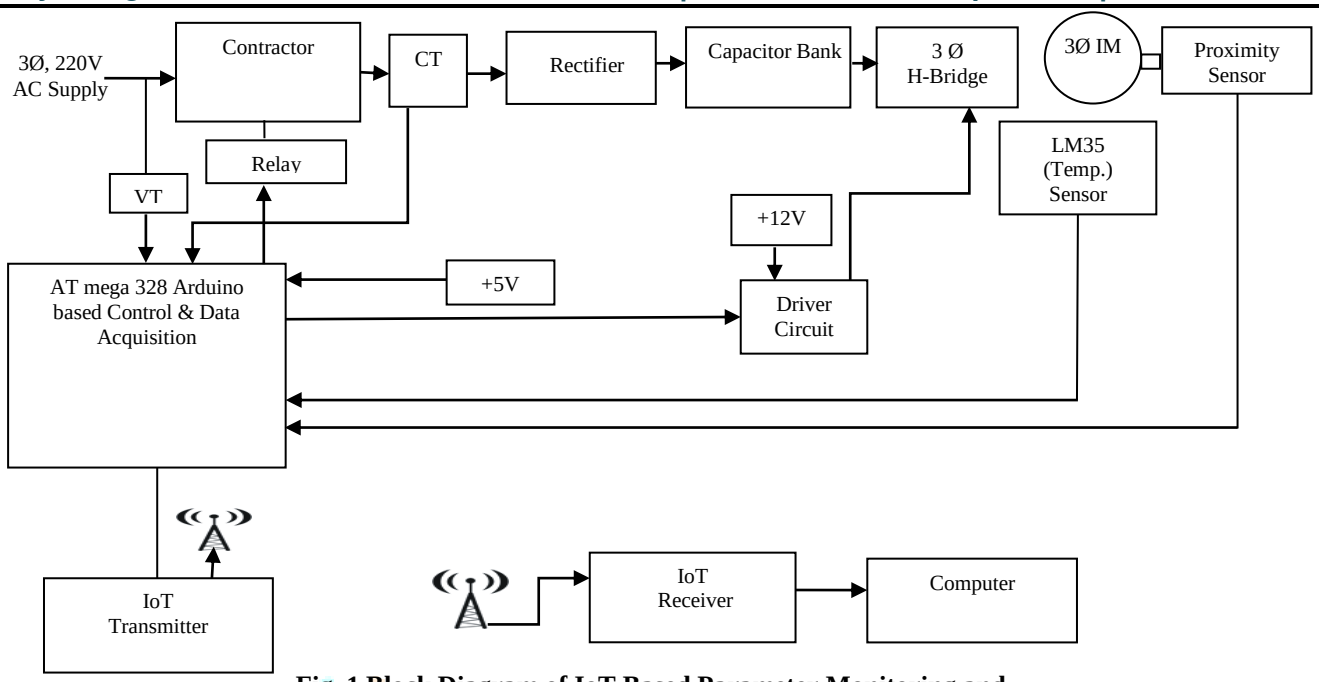

Fig. 1 Block Diagram of IoT Based Parameter Monitoring and Control System of Induction Motor

In this study, experiments were carried out on the three phase IM at ~ 0.3 kW/1400 rpm and 2.5 kW/1200 rpm.

III. HARDWARE DESIGN

This section describes brief description about the components which are used to for configuring Controlling and Monitoring System for induction motor. The Transmitter system comprises of following sub circuits. Fig.2 shows the whole system placed near induction motor and system placed at remote location. Control circuit of induction motor basically consists of the following main sub circuits.

- Rectifier Circuit
- Half H Bridge Circuit
- Driver Circuit
- Circuit for acquiring data from induction motor and controlling of data.

a) RECTIFIER SYSTEM

In this system 230V ac is converted to proper voltage for driving the motor. Input supply is fed to bridge rectifier through ac contractor, current transformer and solid state relay, ac contactor is used for connecting and disconnecting of voltage in the circuit. Bridge rectifier rectifies ac to dc, output of rectifier is then fed to capacitor bank for smoothing the obtained output. C.T and voltage transformer is used for sensing current and voltage of induction motor.

b) DRIVER SYSTEM

ATmega16 is the heart of driver circuit. Resistor network is used on port a and port b of microcontroller to fed logical 0 in case of absence of any data. It uses three pwm channels(OC1A,OC1B,OC2) for generating three phase cycle. Three AND gate for transfer pwm signal toware positive cycle or negative cycle for all three phase. For generating positive and negative cycle of any of any phase two AND gates of 4081 IC is used, AND gate input decides to pass pwm for positive and negative cycle of any phase.

c) HALF H- BRIDGE SYSTEM

In half H-Bridge, IC IR2101 is used for driving n channel IGBT for positive cycle. Output from AND gate of driver circuit is fed to HI-IN and LOW-IN respectively of IR2101.C2 is used for filtering dc supply voltage. With low input high IR2101 switch Q1 for negative cycle. This negative cycle charges C1 with 12 V, when HI-IN is high IR2101 adds C1 voltage with 230V and switch Q2 to output positive cycle. R1 and R2 used to control current of IGBT. By controlling the inputs of AND gate i.e. making AND gate input as low or high and by controlling PWM channels through ATMEGA16 three phase waveform can be generated with three H bridge circuit.

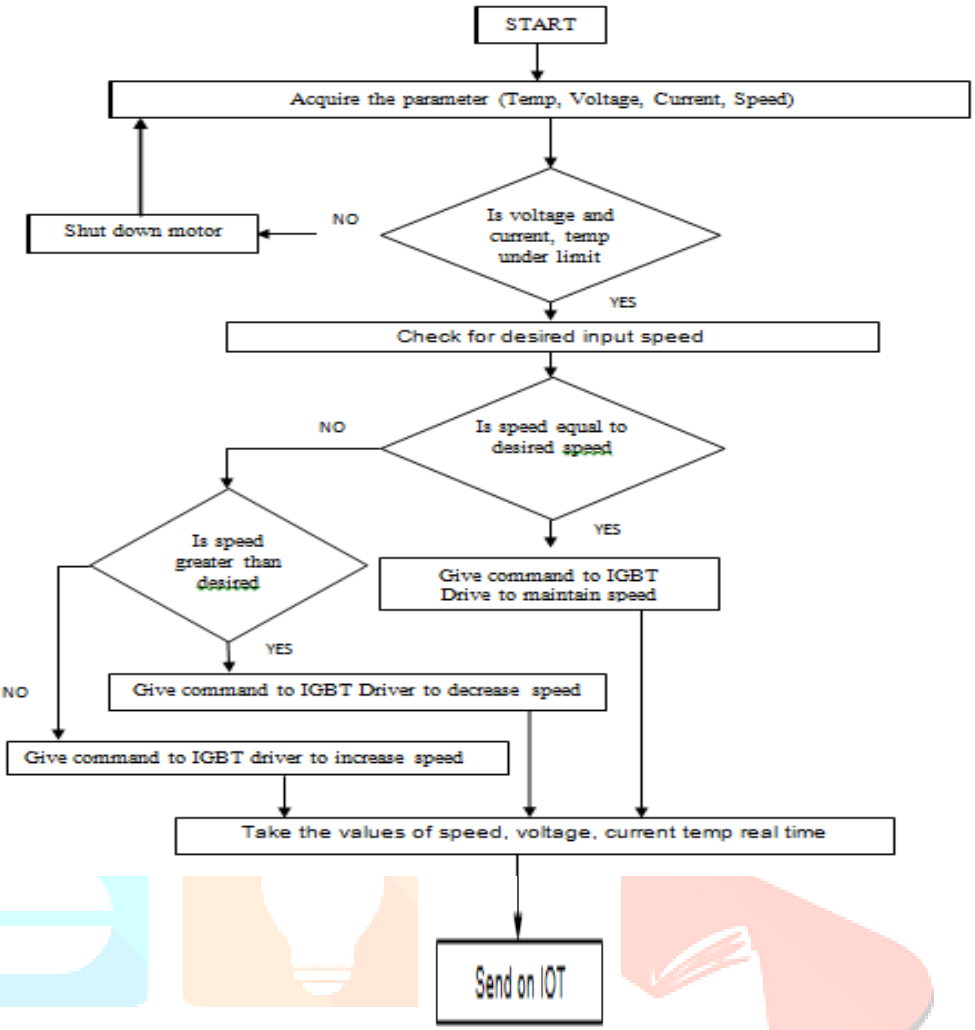

Fig.3 Flow diagram of proposed work

d) Arduino Uno

Arduino is a single-board microcontroller intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analog input pins as well as 14 digital I/O pins which allow the user to attach various extension boards. The Arduino platform was designed to provide an inexpensive and easy way for hobbyists, students and professionals to create devices that interact with their environment using sensors and actuators. Common examples for beginner hobbyists include simple robots, thermostats and motion detectors. It comes with a simple Integrated Development Environment (IDE) that runs on regular personal computers and allows users to write programs for Arduino using C or C++.

e) CONTROL AND DATA ACCQUISITION SYSTEM

Voltage transformer is used to measure input supply voltage to motor. Output from VT is rectified, filtered, stepped down and fed to microcontroller. Current transformer is used input current to motor, filtered, stepped current is fed to microcontroller.LM35 sensor is used to measure body temperature of motor. Output of sensor is fed to Atmega16 through double low pass filter. AT89C51 is used to measure speed and vibrations.AT89C51 start 1sec delay then count all the pulses through proximity sensor by using timer/counter0multiplied with 30 and then send to atmega16 port b and d.. Optocoupler provides isolation between proximity sensor, speaker and the MCU circuit.. To communicate between IoT platform and hardware uses Ethernet Shield is connected with Arduino Tx/Rx pin. Furthermore, IoT platform is ready to monitoring of motor parameter.

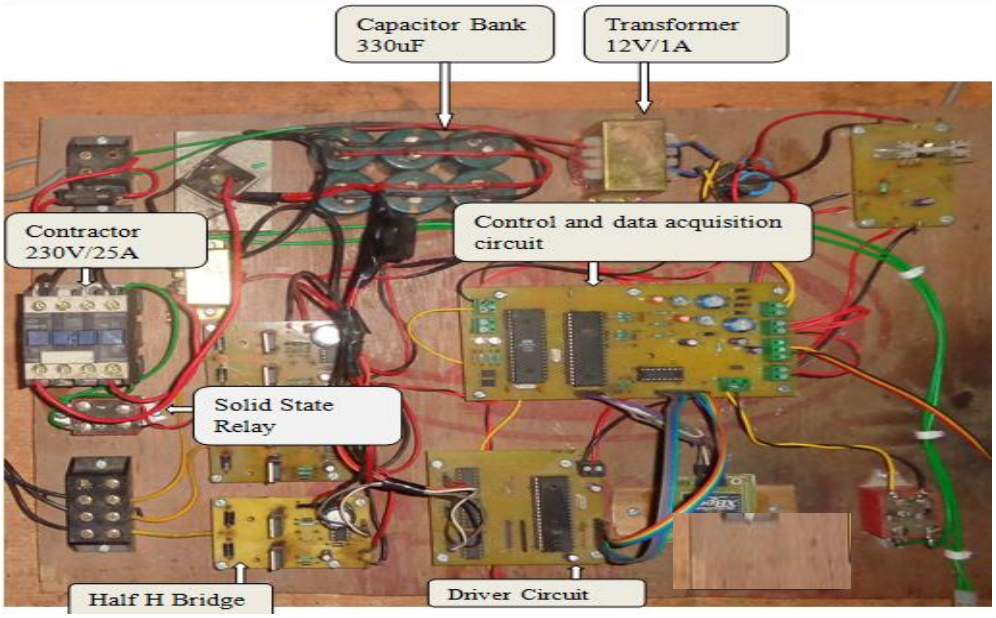

Fig.2 Receiver Control Circuit of Induction Motor

IV. CAYENNE MQTT API FOR IoT

MQTT is a lightweight messaging protocol designed to be used on top of TCP/IP. It uses an event and message (publish-subscribe) methodology that was designed especially for connections where small footprints, unreliable and/or limited bandwidth connections are found. This type of pattern is especially suited for IoT devices that get deployed in the field and often run on battery power and on constrained networks. With MQTT, the publish-subscribe pattern makes use of a broker that is responsible for distributing messages to clients. Clientscan subscribe to varying levels of messages, depending upon how much or what kind of data they are interested.

Fig.3 parameter RPM & Temperature at initial stage on Arduino Serial Monitor.

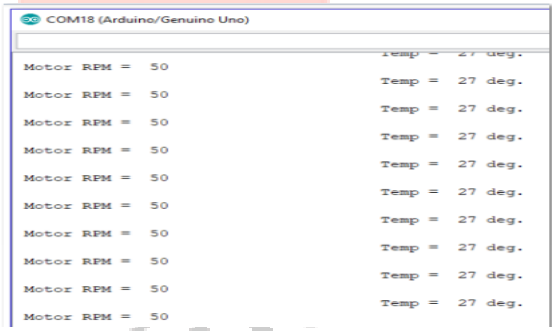

Fig. 4 Temperature at 50 RPM on Arduino Serial Monitor

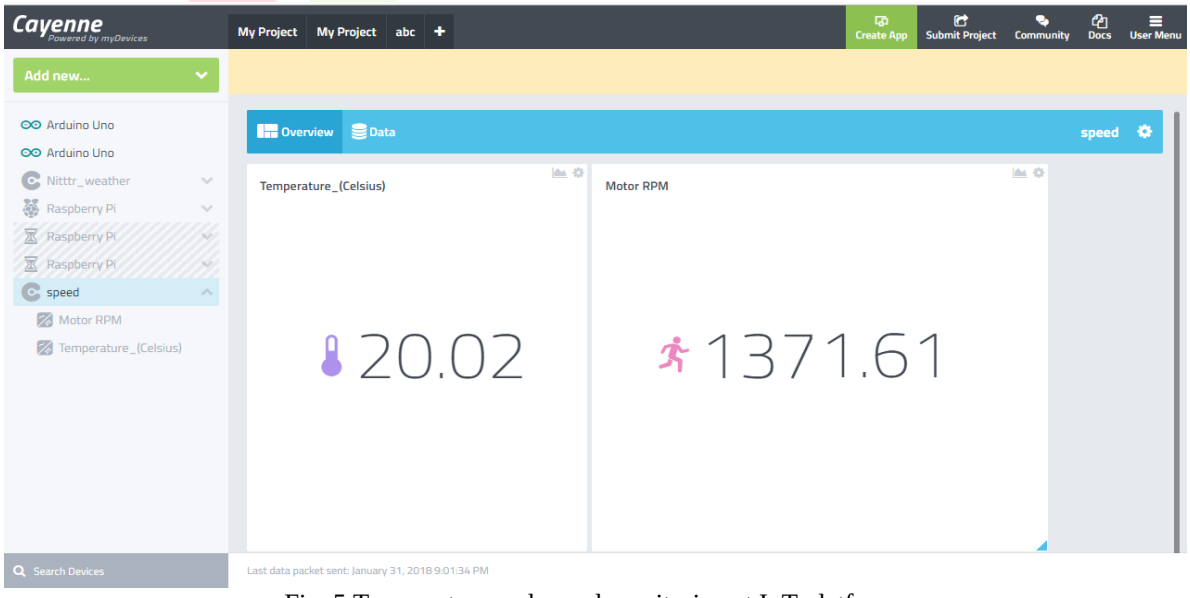

Fig. 5 Temperature and speed monitoring at IoT platform

Table 1. Comparison of IoTwith other controlling systems.

Compared Features	PLC-SCADA	PIC	Classic Control	XBEE	IoT
Cost	High	High	Low	Low	Low
Physical Structure	Small	Small	Big	Small	Very Small
Renewal Opportunities	Easy	Moderate	N/A	Very Easy	Very Easy
Adding Modular System	Possible	Additional Design	N/A	Possible	Possible
Resistance To The Work Environment	High	Additional Security	Low	High	Very High
Finding Fault	Very Easy	Very Easy	Difficult	Very Easy	Very Easy
Communication	Very Easy	Very Easy	N/A	Very Easy	Very Easy
Production Planning	Very Easy	Very Easy	N/A	Very Easy	Very Easy
Security	High	Moderate	Low	Very High	Very High
Development Cost	Low	Moderate	Low	Low	Low
Monitoring Data	Very Easy	Very Easy	N/A	Moderate	High

V. RESULT AND DISCUSSION

A reliability test of the wireless communication is necessary because the proximity of an AC motor generates a noisy environment. It observed that the speed and other parameters of the induction motor measured by directly from laboratory instruments and through IoT which gives a satisfied result. Result is also observed at Arduino serial monitor and IoT on Cayenne. In figures different values of RPM and Temp is observed.

Table.2 Comparison between parameters acquired through IoT with standard meters

S.No.	Temperature			Speed(RPM)		
	IoT	LM35	%Error	IoT	Tachometer	%Error
1	20	19.7	0.03	941	1080	1.4
2.	23	22.2	0.08	1110	1083	0.27
3	25	24.5	0.05	1080	1085	0.05
4	27	26.3	0.07	1080	1085	0.05
5	30	29.8	0.02	1080	1085	0.05
6	31.5	30.9	0.06	1080	941	1.4
7	33	32.6	0.04	1110	1083	0.27
8	35	34.9	0.01	1080	1084	0.04

VI. CONCLUSION

In this study, a parameter monitoring system for induction motors based on IoT is achieved and tested successfully. The system developed is capable to perform such operations as running the motor though RF, stopping it, measuring, monitoring the most parameters of the motor like temperature, speed. All of these values can be transferred to the IoT platform, displayed on the interface, represented graphically, transferred into an Excel file to store them for a long time Monitoring the basic values of the induction motors were done and achieved in various ways. Comparison of positive and negative aspects and its cost was done. Comparison of IoT with other controlling systems is shown in Table 3. The system developed in this study has been tested experimentally and it has been observed that the system operates without any failure and it has more performance than the similar ones. During the experimental tests, no problem has been observed either communicating the IoT platform, or integrating the hardware units used for controlling and monitoring the induction motor. The system developed can be used for not only industrial applications but also educational purposes; it means, the whole system may be useful to colleges that have vocational, technical, and industrial education. Instructors can use the system presented as a supporting teaching material, and it can be adapted in experimental researches successfully.

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